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ARTICLE VI.

ON THE SHOULDER-GIRDLE AND EXTREMITIES OF ERYOPS.

BY E. D. COPE.

Read before the American Philosophical Society, January 20, 1888.

Our knowledge of the genus *Eryops*, which is one of the most abundant types of the Rhachitomous Batrachia, extends to the skull in general, the vertebral column, the pelvis, humerus, femur, and tibia.* The shoulder-girdle, fore foot, and hind foot are unknown, although the hind foot of a species from the coal measures provisionally referred to this genus has been described.† In the present paper I can describe the missing parts from a skeleton found with skull of the *Eryops megacephalus*, which was obtained in Texas, in the Permian beds, by that indefatigable and skillful collector, Jacob Boll.

The shoulder-girdle embraces scapula, coracoid, præcoracoid, clavicle, and episternum. The scapula is flat and elongate; its superior portion is rather thin, and gradually expanded and rounded like the end of a boat's oar. Below it passes directly into the coracoid and præcoracoid, the suture becoming obliterated early. The præcoracoid is larger than the coracoid, is convex downwards, while the coracoid is convex upwards. This leaves a fossa at their line of junction on both surfaces, and through this the coracoid foramen is pierced. The posterior border of the coracoid is regularly convex, and is not notched as in the Pelycosaurian *Theromora*.‡ The internal and anterior border of the præcoracoid form a continuum of convex outline, the former passing rather abruptly into the latter. The clavicles are curved bones, forming, as usual, the anterior border of the shoulder-girdle. Their superior portion is directed upwards and

* Proc. Amer. Philos. Soc., 1880, p. 52.

† Trans. Amer. Philos. Soc., 1886, p. 289.

‡ *Theromora* is substituted for *Theromorpha*, a name which had been previously used.

backwards, in the form of a band, and it does not extend so far on the scapula as is usual with Reptilia, and terminates in a rather abrupt flat apex. The inferior portion becomes horizontal and is directed forwards at an open angle, meeting its fellow on the middle line. This portion expands a little, presenting a thin edge posteriorly, and an oblique truncation inwards and forwards with grooved and finely digitate edge, at the distal end. The clavicles underlap the episternum. The latter is a flat discoidal bone rather wider than long, with a regularly convex, thin posterior edge. The lateral portions are overlapped by the præcoracoids. The anterior border is coarsely toothed, as though for the attachment of an omosternum. Of true sternum I do not observe any trace of sternum.

The differences between the shoulder-girdles of Eryops and of Actinodon (Gaudry) are considerable. The latter has been described and figured by Professor Gaudry, and I have had, through his kindness, the opportunity of examining the typical specimen. An obvious difference is that the latter genus, as in many Stegocephali, has the episternum and proximal parts of the clavicles sculptured on the inferior (external) face, with exostosis, which occupies the true skin. The clavicle articulates externally with a slender bone, which is regarded by Gaudry as clavicle. It occupies the position of the anterior thickened portion of the scapula in Eryops. What its true homology is is not clear to me, but it is in the position of the epiclavicle of the fishes. The scapula is coössified with the præcoracoid. The true coracoid is very small, less even than in Eryops. An easily observed peculiarity of Actinodon is that the episternum is longitudinal diamond-shaped, as in Stegocephali generally.

The shoulder-girdle of *Cricotus* is in my collection, but is so difficult to extricate from the matrix that its characters are not all clear. The clavicles are expanded inwards over the edges of the episternum as in Actinodon, and more widely than in Eryops, and the expanded surface is sculptured as in that genus. The slender part of the clavicle is strongly curved upwards, as in Actinodon. The episternum is also produced posteriorly as in Actinodon.

As compared with the Pelycosaurian reptiles, the shoulder-girdle of Eryops and its allies shows several important points of resemblance, some of which I have already described. Such are the small coracoid and large præcoracoid, both coössified with the scapula in adults. The episternum in Dimetrodon at least, differs in its long narrow posterior prolongation, as in Lacertilia.* The clavicles have not been described in Clepsydropsidæ, although they have been in Diadectidæ.† In the latter the clavi-

* Transactions Amer. Phil. Soc., 1886, p. 292, Pl. III, fig. 5, where I inadvertently called it sternum.

† Proc. Amer. Phil. Soc., 1883, p. 635.

cles are narrow, and expand but little at their contact with the episternum. They form a symphysis behind and below the episternum, which has an exclusively anterior and superior exposure. The latter is wedge-shaped in longitudinal section, thinning out rapidly posteriorly, where it is not produced on the middle line as in the *Clepsydropidæ*.

In *Dimetrodon* the form of the clavicle is similar to that of *Cricotus*. That is the inferior portion is bent inwards at right angles to the vertical portion, and is greatly expanded in the anterior direction. Its inner margin is finely digitate by the production of numerous radiating ridges. This portion of the shoulder-girdle projects forwards in the manner of the so-called epiplastral bone of the plastron of the *Testudinata*. With the episternum in place this part of the shoulder-girdle of *Dimetrodon* resembles the anterior lobe of the plastron of a tortoise. A narrowing of the præcoracoid and scapula, and an elongation of the coracoid, would give the *Testudinate* shoulder-girdle. Such a change in some unknown member of the *Theromorous* order, together with modifications of the abdominal costoids, has given origin to the order *Testudinata*.

The anterior leg of *Eryops* is short, and very robust. The anterior foot has the character, entirely exceptional in the *Batrachia*, of having five digits. The humerus has been already partially described.* It resembles very nearly that described by Professor Gaudry to his *Euchirosaurus rochei*.† It is short and very robust, and the extremities are greatly expanded and almost at right angles to each other. The proximal extremity with its band-like articular surface, is strongly decurved antero-exteriorly, ending in a strong protuberance. The distal end has an enormous plate-like expansion of the internal epicondyle, greater than that exhibited by *Euchirosaurus rochei*. The condyle is subglobular and large, and the external epicondyle is partly posterior to it. This epicondyle forms a process flattened on the posterior face, which is continued upwards into the shaft of the humerus, and is bounded below by a semicircular sharp edge. On the external border of the shaft above the notch between the condyle and the external epicondyle, is a short, obtuse, vertically compressed process directed at right angles to the shaft. A similar process exists in *Euchirosaurus rochei* (Gaudry).

The ulna has little or no olecranon, and has a strong glenoid cavity on the superior aspect for the condyle of the humerus. It resembles much that of a pelycosaurian. The shaft is slender, and the distal extremity is not expanded. At the latter place the superior face is flat, and the inferior is convex. The radius is a short

* Proc. Amer. Phil. Soc., 1880, p. 54.

† Enchainements du Monde Animal; Fossiles primaires, 1883, p. 277.

robust element, with both extremities expanded, the distal much more so than the proximal. The latter is truncated, with a wide oval outline, and rests, as in land vertebrates generally, on the coronoid process of the ulna. The shaft is suboval in section, and is much stouter than that of the ulna. The distal end is convex and is horizontally expanded so as to rest on three carpal elements: radiale, centrale 1, and intermedium. Its inferior face is flat distally, and the distal outline is openly angulate with subequal faces; one principally for the radiale, and the other principally for the intermedium.

The carpus consists of ten, possibly of eleven elements. Four of these are in the proximal row, viz., radiale, centrale, intermedium and ulnare. The second row consists of five carpalia. Between the two rows is centrale 2, which appears to have a small centrale 3 separated from its external end, but on the palmar face, the distinction is not clear. The carpals are, in the order of size, as follows: ulnare, centrale 1, centrale 2, radiale, carpal 5, intermedium, carpal 2, carpalia 1, 4 and 3. The metacarpals are flattened, with the extremities truncate and expanded; the proximal the wider; the distal without indication of condyles. The third and fourth are twice as long as wide distally, and the first is as wide as long. The fourth digit is the only one in the specimen in which the phalanges are preserved. There are three of them, the ungual very small and subconic in form, the inferior face flatter than the superior. The two other phalanges are about as wide as long.

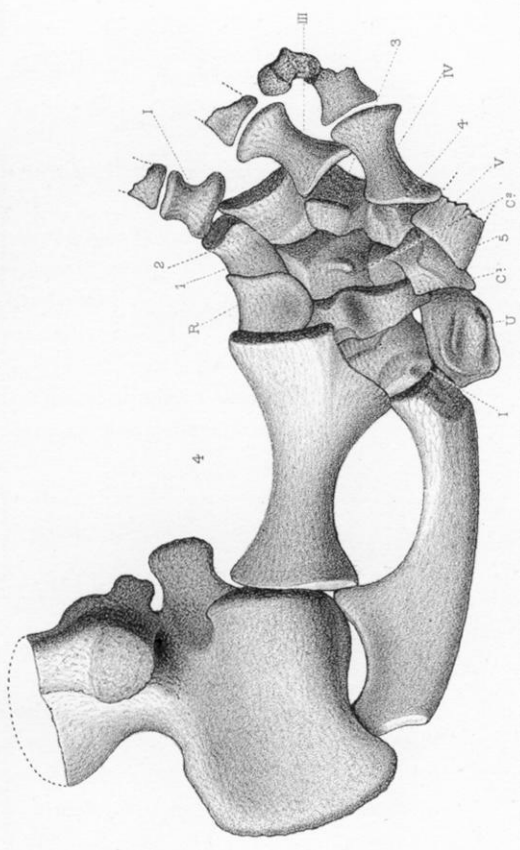
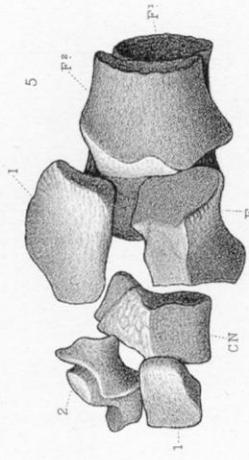
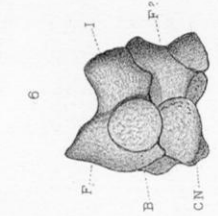
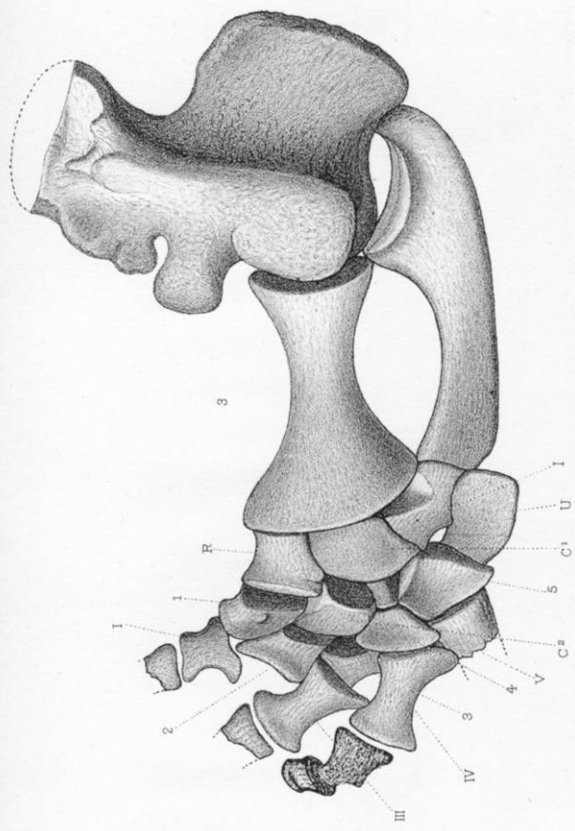
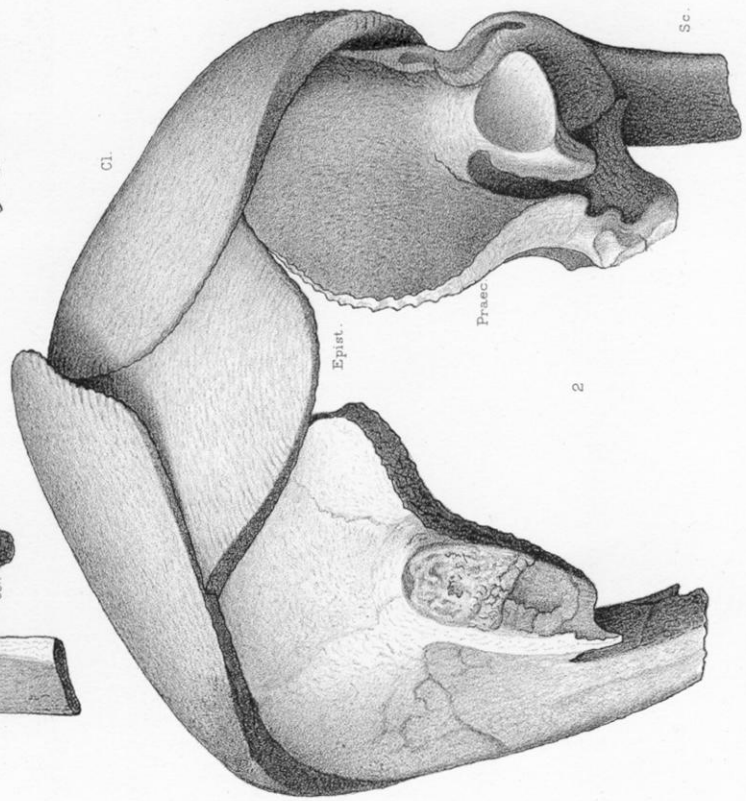
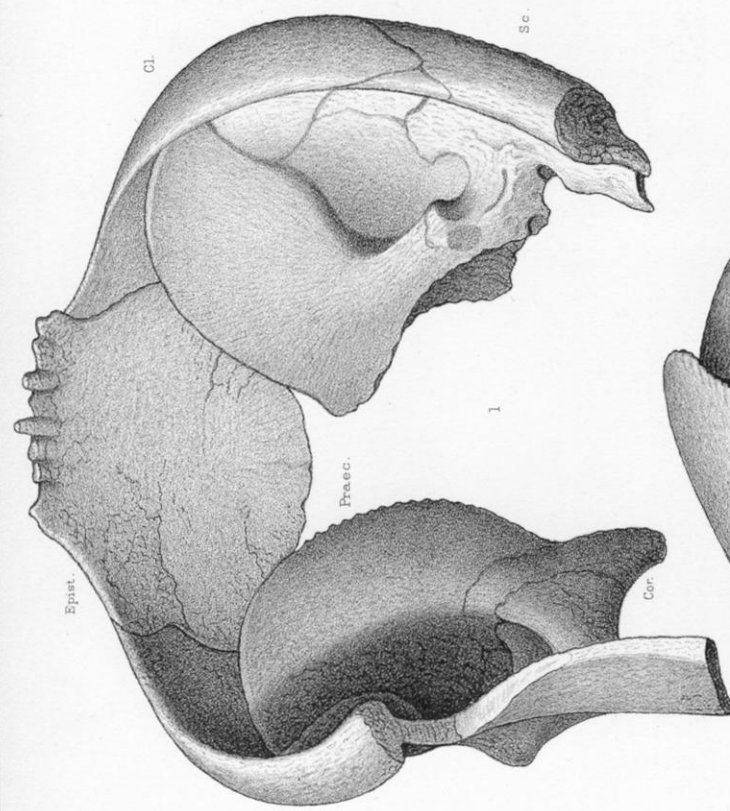
	<i>Measurements.</i>	<i>MM.</i>
I. Shoulder-girdle.		
Width at anterior border of præcoracoid		235
Diameters episternum {	anteroposterior.....	110
	transverse.....	130
Greatest (inferior) width of clavicle.....		70
Length of coracopræcoracoid on upper surface.....		160
II. Anterior leg.		
Humerus, greatest width proximally.....		90
“ “ “ medially.....		40
“ “ “ distally.....		103
“ “ length (part estimated).....		120
Ulna, length		112
Ulna, transverse diameter {	proximally.....	45
	medially.....	15
	distally.....	30
Radius, length.....		78
Radius, transverse diameter {	proximally.....	42
	medially.....	27
	distally.....	60
Length of carpus from ulna to m. iv.....		62
Width of carpus, proximal row.....		95
Length of fourth digit.....		78

This carpus and fore foot is noteworthy from the presence of five digits, an unusual character in the class Batrachia. The genus *Archegosaurus* has but four, although according to Baur* there are five carpalia. In the presence of two centralia, *Eryops* agrees with occasional specimens of both *Cryptobranchus allegheniensis* and *Megalobatrachus japonicus* (Wiedersheim). If three centralia are present, the resemblance to *Archegosaurus decheni* is greater, where, according to Baur, there are four.

The posterior foot found at the same time and place as, and having appropriate proportions to, the parts already described, is not so well preserved. The distal elements of the leg have subequal widths, but they are folded back to back so that one of them has lost its tarsal connections. One of them, perhaps the tibia, remains articulated to two proximal tarsals, probably tibiale and intermedium. The approximated surfaces of these bones are very thick, as is the internal face of the tibiale. The external face of the intermedium is, on the contrary, thinned out. The tibiale is characterized by the presence of a round, flat, discoid tuberosity on its ? posterior face, which resembles the disc of a button. Distad from the tibiale is a large transverse centrale, in the position of the Pelycosaurian and Mammalian navicular. It articulates with the distal extremities of the intermedium as well. Its distal face articulates with two tarsalia, which are somewhat displaced in the specimen. The remainder of the foot is in two separate pieces, which represent probably parts of both posterior feet. In one of these I count five metatarsal bones very much displaced. Two of them are of rather small size. In the other block is a series of four consecutive phalanges, all wider than long. The distal one is quite small, but the ungual is not present.

Two small tarsi from opposite sides of perhaps the same individual were found mixed with the bones of the larger animal. They belong to an allied form. The tibiale has the same button-like disc on one of its faces, and it articulates distally with a navicular-centrale. The ? intermedium is a shorter bone and unites with a single element, which may represent a centrale 2, or a cuboid. It *appears* to articulate distally with two elements, though the matrix does not let it be determined whether the lines observed are sutures or fractures. And it is not certain whether the two supposed elements are tarsalia or proximal ends of metatarsalia. There is, as in the larger tarsus, no indication of an exterior or fibular series of tarsals. The bone referred to as possibly cuboid, rises on the external side of the level of the proximal face of the intermedium, and may be therefore a fibulare, which presents very little proximal facet. This tarsus strongly suggests the presence of but four digits.

* Beiträge z. Morphogenie d. Carpus u. Tarsus d. Vertebraten, 1887, i, p. 53.



<i>Measurements of Posterior Foot.</i>				<i>MM.</i>
Transverse diameter distal end of tibia.....				51
“ “ “ “ fibula				50
Diameters of tibiale	{	longitudinal (greatest).....		38
		transverse (proximally)		28
Diameters intermedium	{	longitudinal		45
		transverse		31
Length of centrale 1 (internal face)				20
“ “ tarsale 1 (internal face).....				14
“ “ metatarsal 2 or 4.....				39
“ “ “ 3.....				40
“ “ “ 2 or 4.....				34

EXPLANATION OF PLATE.

Fig. 1. Left anterior limb of *Eryops megacephalus* from above; *1a*, the same from below.

Fig. 2. Portion of right posterior leg and foot of the same, from front.

Fig. 3. Tarsus of a small species allied to *Eryops*, from behind.

Fig. 4. Shoulder-girdle of *Eryops megacephalus* from above; *4a*, the same from below.

All the above figures two fifths natural size, except Fig. 3, which is one-half.

U, Ulnare; *I*, intermedium; *R*, radiale; *C*, centrale 1; *C2*, centrale 2; *F*, fibulare; *CN*, centrale naviculare; *B*, button-like tuberosity; *Ti*, tibia; *Fi*, fibula; *1-5*, carpalia and tarsalia; *I-V*, metapodials.